PCMAG Solenoid Upgrade

AIDA 1st Annual Meeting, Mar. 28. 2012

R. Diener, DESY

Overview

Introduction

Test Beam Setup

R&D Goals, Large TPC Prototype

PCMAG

AIDA PCMAG Modification

Modification Plan

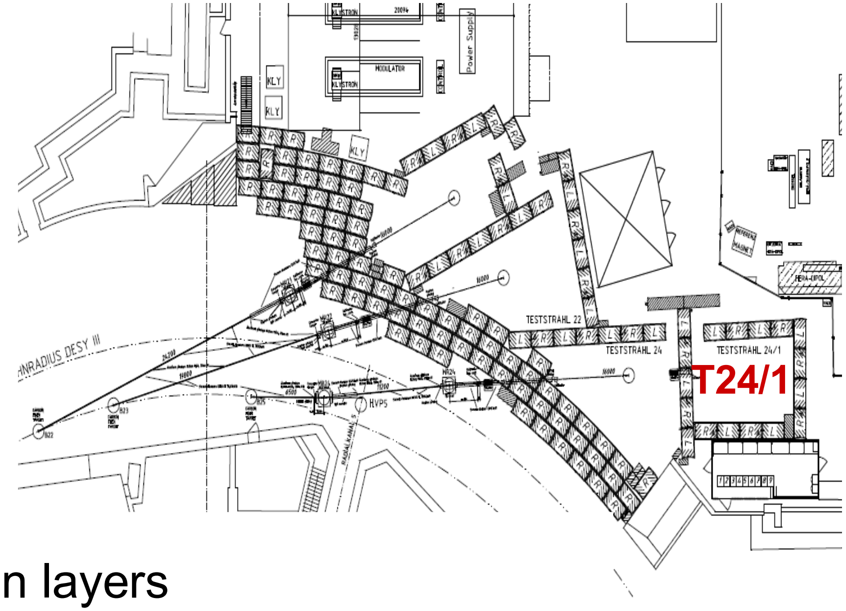
Modification Details

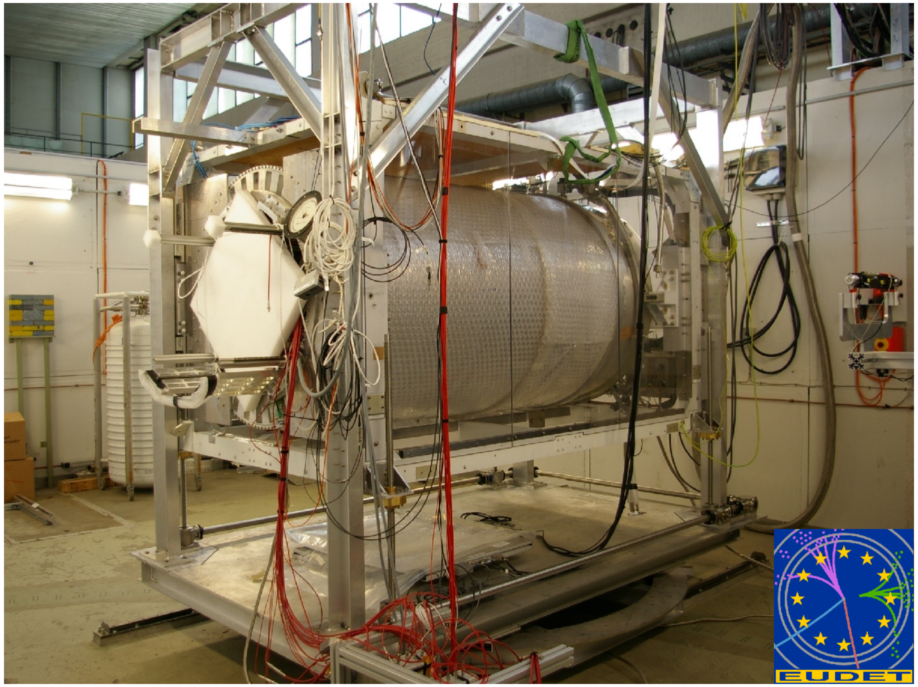
Test Beam Area

Time Schedule

Test Beam Setup

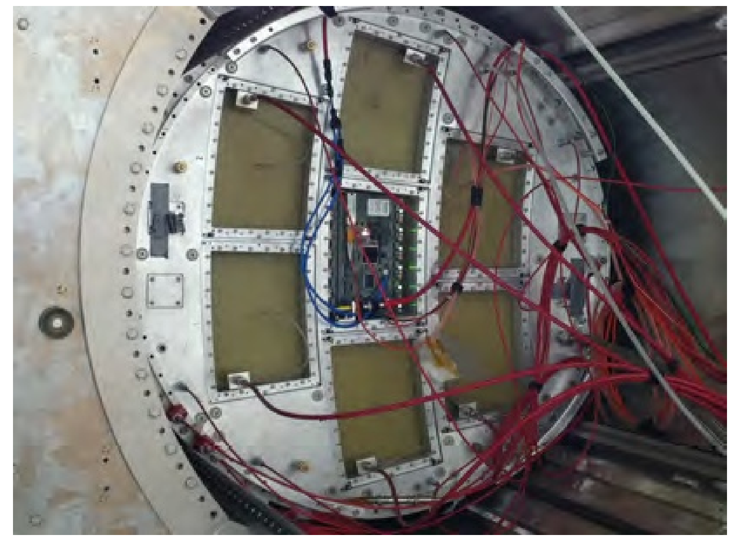
- Set up in DESY II test beam area T24/1 (e+/e- from 1 to 6 GeV/c):
  - Large field cage with modular end plate
  - PCMAG magnet mounted on movable
  - Lifting stage (3 axis)
  - HV, gas and slow control systems
  - Cosmic and beam trigger
  - Laser calibration system, planned: external silicon layers

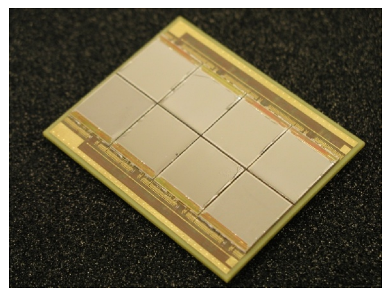


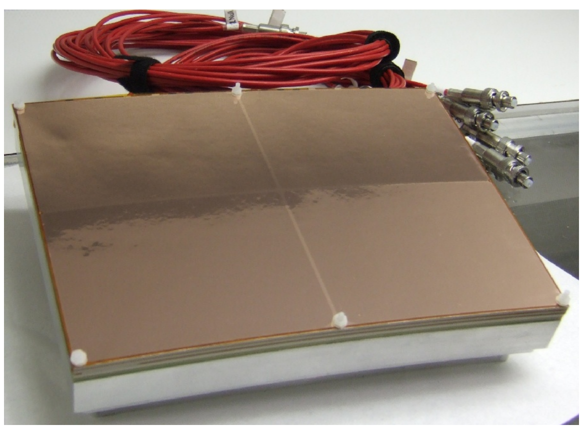


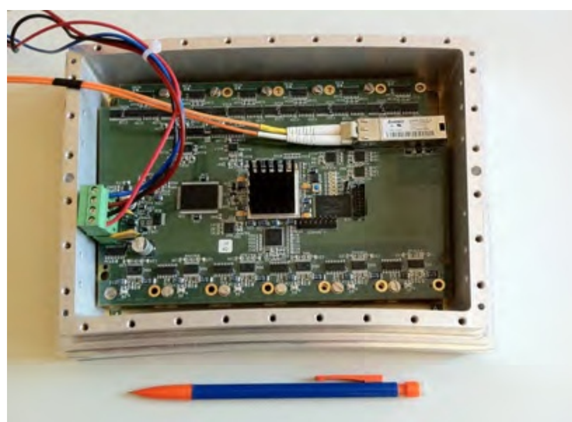
Large TPC Prototype

- Goal: study in practice the design and fabrication of all components of a MPGD TPC in larger scale
- Large TPC Prototype:
  - Light weight; made of composite materials
  - ∅ 72cm, L= 61cm
- Modular end plate
  - Up to 7 read-out modules
  - Size/shape similar as forseen in the final detector







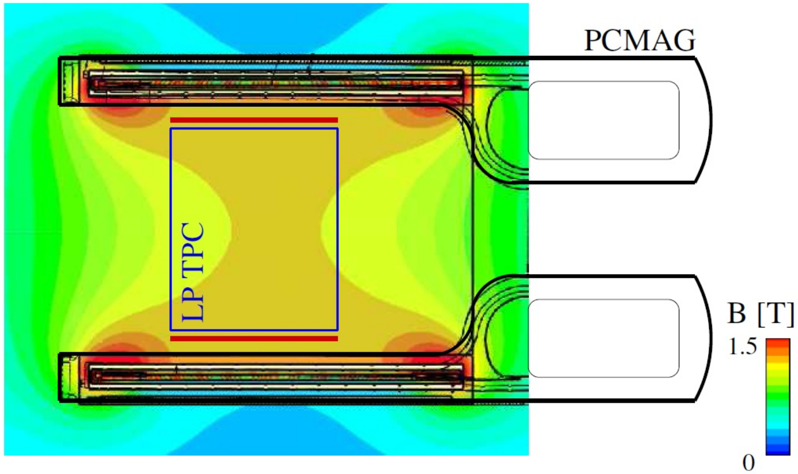


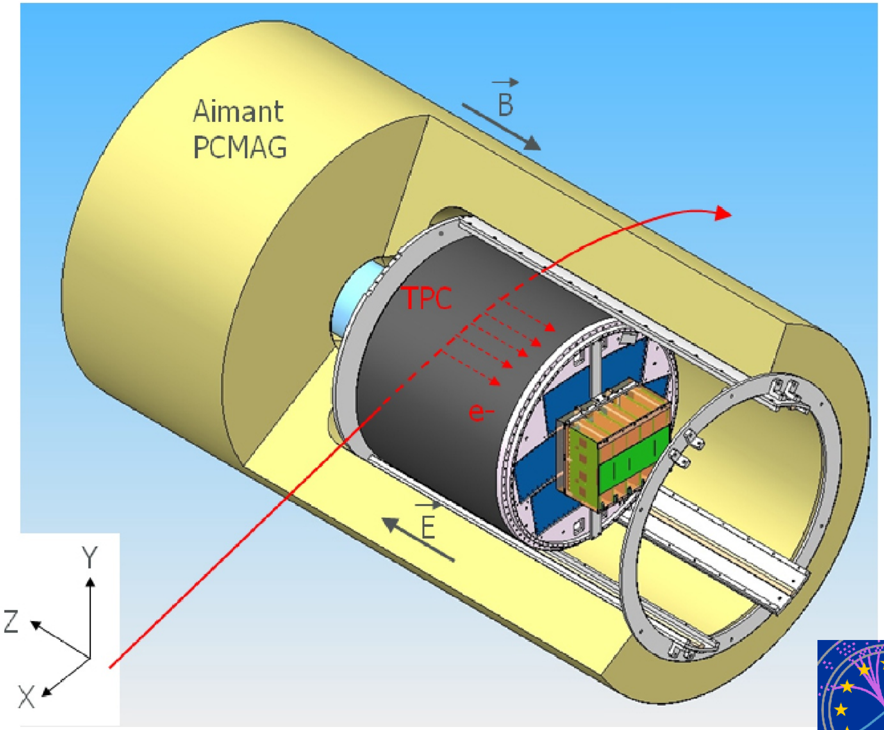
Test Beam Usage

- **2008:**
  - Nov-Dec Micromegas module w/ resistive anode (T2K electronics)
- **2009:**
  - Feb-Apr 3 Asian GEM Modules w/o Gating GEM (3,000ch ALTRO electronics)
  - Apr TDC electronics with an Asian GEM Module
  - Apr-May Maintenance of PCMAG
  - May-Jun Micromegas w/ two different resistive anodes (New T2K electronics)
    Setup and test of laser–cathode calibration
  - Jun GEM+Timepix (Bonn)
  - Jun Installation of PCMAG moving stage and SiTR support
  - Jul TDC electronics with an Asian GEM module
    ALTRO electronics study w/ Asian GEM
  - Jul-Aug Full installation of PCMAG moving stage
  - Aug Micromegas w/o resistive anode with laser-cathode calibration
  - Sep Bonn GEM module (small area GEM with ALTRO electronics)
  - Nov Micromegas with SiTR
- **2010:**
  - Mar Micromegas using PCMAG movable table.
  - Mar+Sep
    3 Asian GEM modules w/ gating GEM or a field shaper using the PCMAG movable table (7616ch ALTRO electronic)
  - Dec Octopuce (8 Ingrids) test on LP with 1T (Saclay/Nikhef)
- **2011:**
  - Apr First test of DESY GridGEM module (B=0T)
  - May New AFTER electronics for Micromegas
    Installation of new cosmic trigger logic
  - Jun/Jul DESY GridGEM module with ALTRO read-out
  - Jul PCMAG shipped to Japan
- **2012:**
  - Mar Return of PCMAG
  - Apr-Jun Installation of upgraded PCMAG
  - Summer / Autumn (tentative):
    - Test with 7 Micormegas modules with integrated AFTER electronics, Test of Japanese GEM modules, Test of DESY GridGEM module

PCMAG

- PCMAG (designed for airborne experiments)
  - **P**ersistent **C**urrent, superconducting **MAG**net
  - Thin coil and wall ($0.2X_0$), no return yoke
  - Liquid Helium reservoir
  - Moved to DESY in Dec 2006
  - Tested and mapped in 2006-2007 (cooperation of DESY, KEK and CERN) Accuracy of 10^{-4}
- Dimensions and data:
  - Coil: ∅ 1.0 m, ↔ 1.3 m, weight: 460 kg
  - Central magnetic field: up to 1.2T
  - Liquid He capacity: 240L (max. 10 days)
  - Operational current: ~430A (1T)





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AIDA PCMAG Upgrade

Modification Outline

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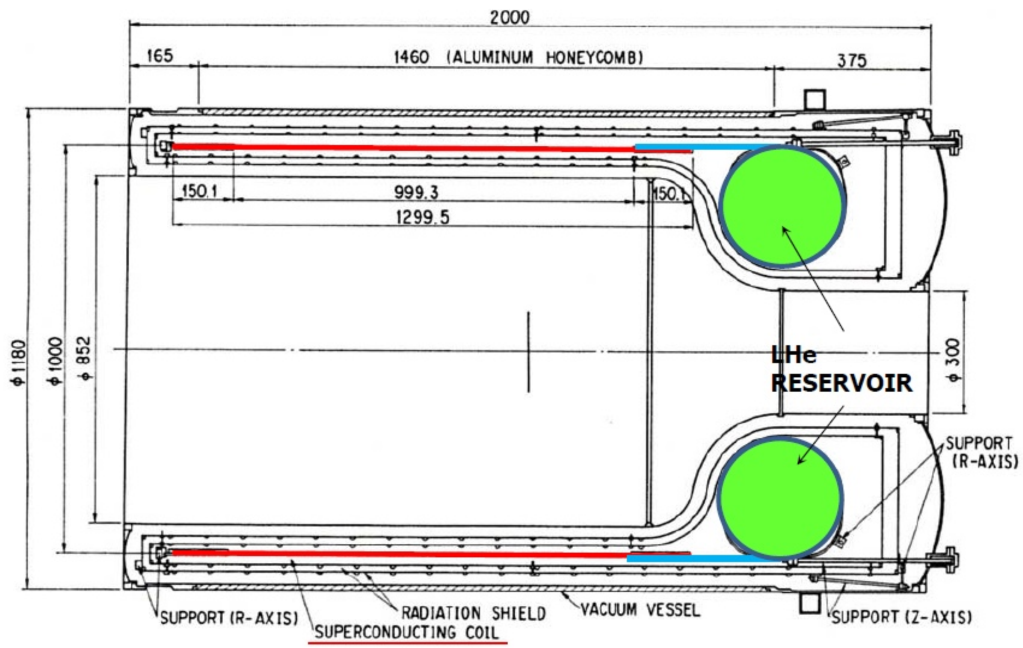
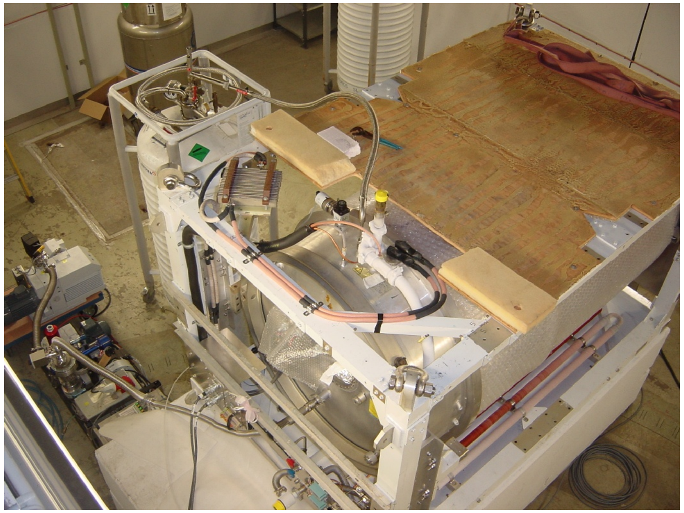
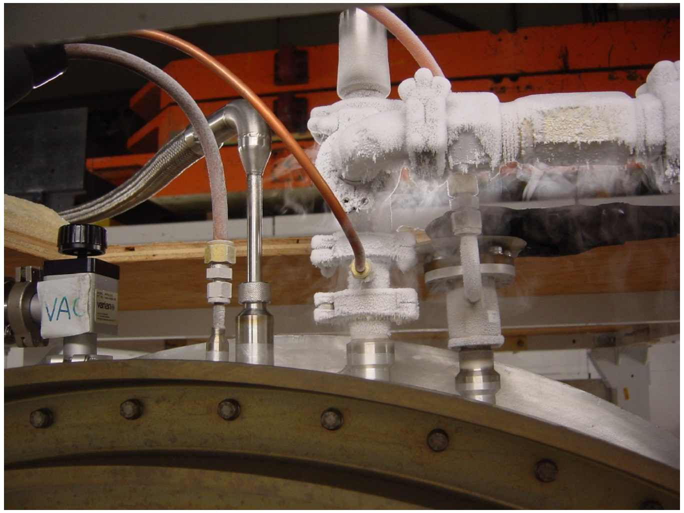
PCMAG Upgrade Goal

- Up to now:
  filling manually with liquid Helium
  - Expert work: many steps that have to be followed carefully
  - Longer running times (many fillings): probability of pipe blocking due to small amounts of air in the system







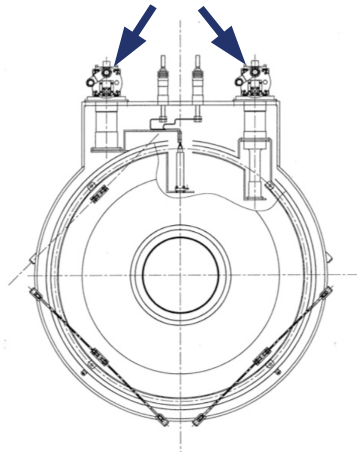
PCMAG Upgrade Goal

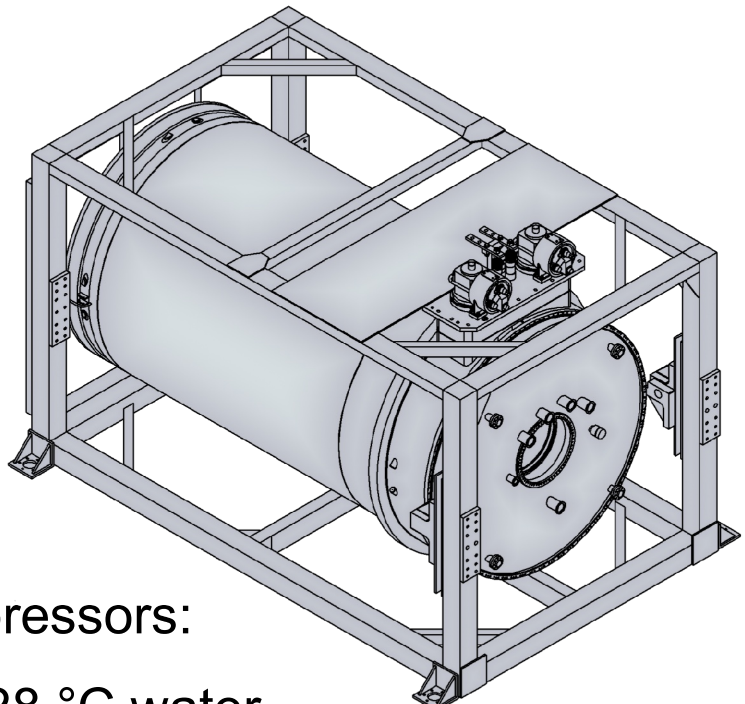
- Upgrade in AIDA (with contrib. from KEK & DESY):
  PCMAG without liquid Helium using cryo coolers (closed circuit system)
- Compact GM cryo-coolers now available (with efficient regenerator) and technically rather easy modification from LHe cooling to cryo-coolers
- Advantages:
  - No liquid Helium filling:
    - No pre-cooling
    - No recovery of Helium gas
    - Save liquid Helium (1000l for initial cooling and ~250l/week)
  - Safe, easy and efficient operation (by R&D groups)
    - No handling with cold gases
    - Simple *switch-on* procedure
    - Standard way of operation (no persistent current mode)
      → increased safety in case of emergency-off
  - Long-period, *"unattended"* operation possible
  - Portability to bring it to any beam line in the world

PCMAG Upgrade Details

- PCMAG become longer by about 10 cm (but still inside *NASA frame*)
- Two cryo coolers *(Gifford McMahon cycle)* will be added to vacuum vessel:
  - One two-stage cooler for the coil and the radiation shield (4 resp. 50 K)
  - One one-stage cooler for the current leads (50 K)

cryo modules
are installed





- 2 Helium gas compressors:
  - Water cooled: 7-28 °C water, min 7 l/min @ 28°C
  - Power: 6.5-7.2 W (380 V, 13 A)
- Cooldown will take about 10 days

Screenshots from http://www.shicryogenics.com

SRDK-408D2 Specification Chart

Model		SRDK-408D2-A71A SRDK-408D2-F50L SRDK-408D2-F50H SRDK-40
1st Stage Capacity	Watts @ 50 Hz	34 W @ 40 K
	Watts @ 60 Hz	44 W @ 40 K
2nd Stage Capacity	Watts @ 50 Hz	1.0 W @ 4.2 K
	Watts @ 60 Hz	1.0 W @ 4.2 K
Lowest Temperature 2nd Stage †		<3.5 K
Cooldown Time 2nd Stage †		<60 Min. (4.2 K)
Coldhead	Ambient Temperature	5~35 °C ‡
	Weight	18.0 kg (39.7 lbs.)
	Maintenance Interval	10,000 Hours

F-50 Indoor Water-Cooled Compressor

F-50	
Electrical Power†	3 Phase 200 V, 50/60 Hz [Low Volt] 380, 400, 415 V, 50 Hz or 460-480 V, 60 Hz [High Volt]
Ambient Temperature‡	5-35 °C (41-95 °F)
Minimum Cooling Water Requirement and Temperature Range*	4-28 °C (39-82 °F)‡ Min. 7 L/min (1.9 gal/min) at 28 °C
Weight and Dimensions	120 kg (265 lbs.) 591 mm x 450 mm x 588 mm (23.3" x 17.7" x 23.2") HxWxD
Maintenance Interval/ Adsorber Exchange	30,000 Hours

Thermal Loads / Cryo-Coolers

Thermal loads	1st stage	2nd stage (4K)
Radiation	30W	0.5W
Thermal conduction	1W	0.02W
Current leads	42W	0.1W
Sum ∑	73W	0.62W

Two-stage 4k cryo-cooler

To cool coil and the 1st -radiation shield

Sumitomo (SHI) Cryogenics 4K cryo-cooler RDK-408D2 with a compressor F-50:

1st Stage Capacity : 34W @40K @5 0Hz

2nd Stage Capacity 1.0W @4.2K @ 50Hz

One stage 10K cryocooler

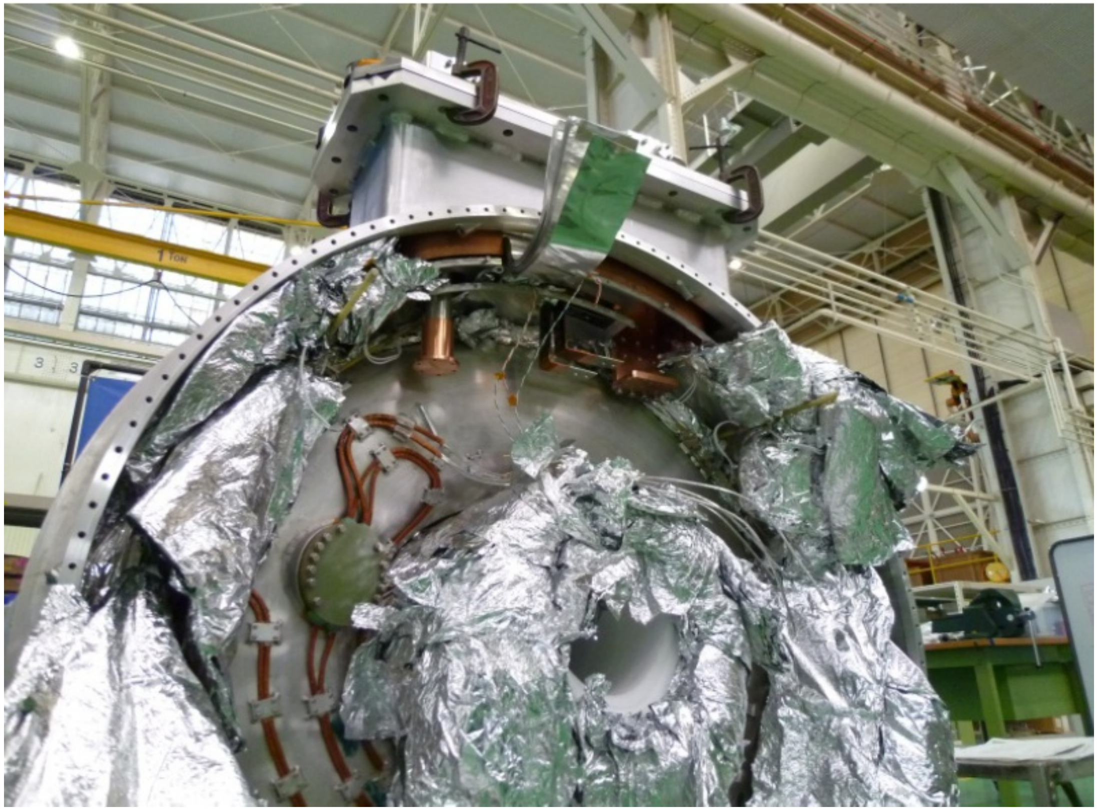
To cool HTc-superconductive current leads

Sumitomo (SHI) Cryogenics 10K cryo-cooler RDK-400B with a compressor F-50

1st Stage Capacity : 54W@40K @ 50Hz

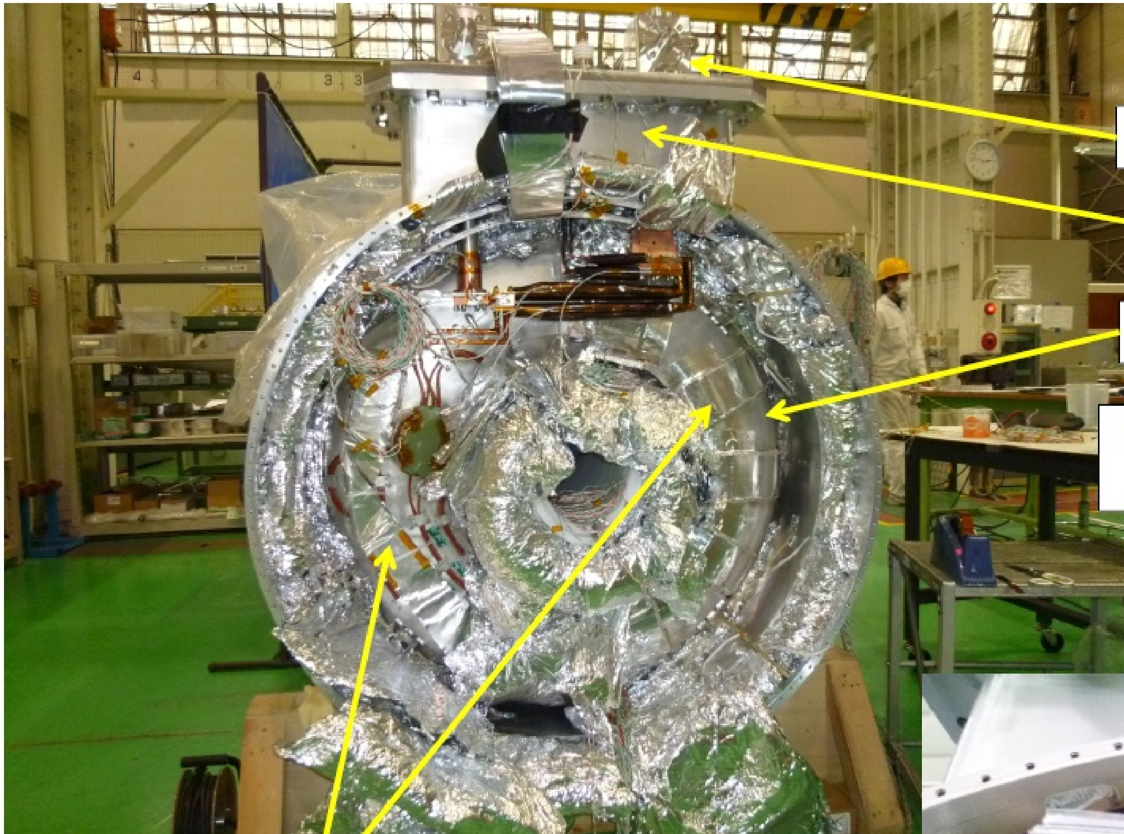
http://www.shicryogenics.com/

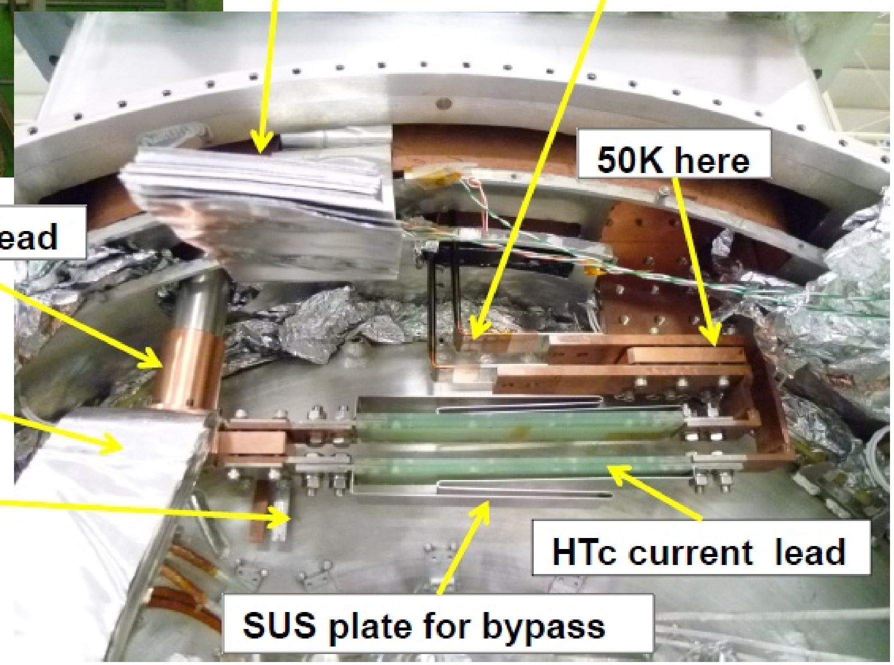
PCMAG Modification I



PCMAG Modification II

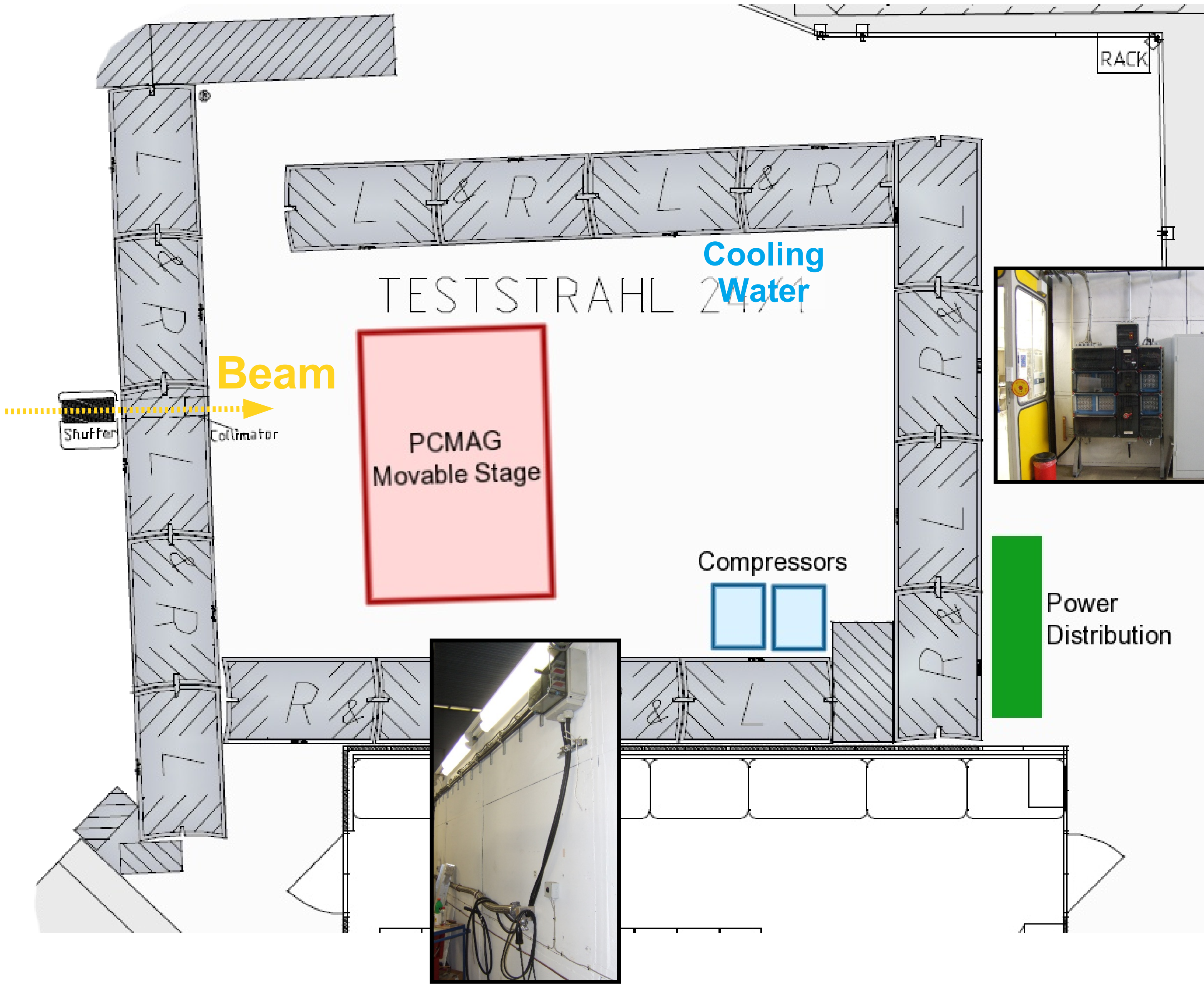
Some Details inside



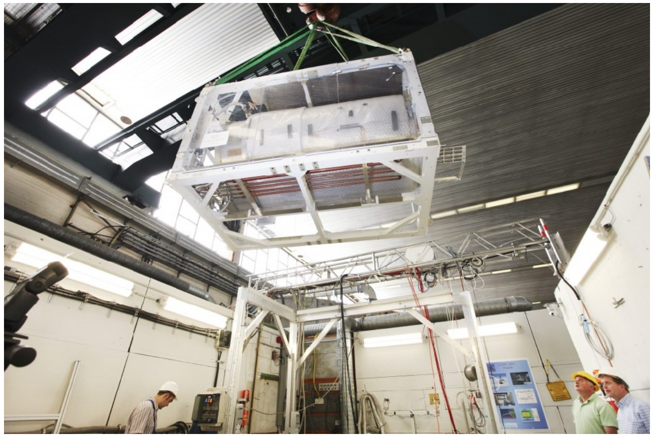


Test Beam Area

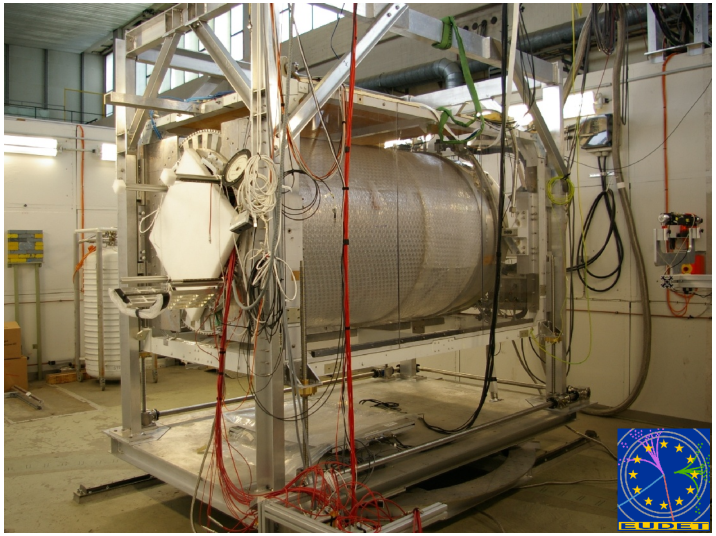
- Power:
  - improved cables to magnet up to 448A, 1kV
  - new power lines for compressors: 35A each
- Instead of water chiller: cooling water
  - 7 °C
  - from central DESY lines

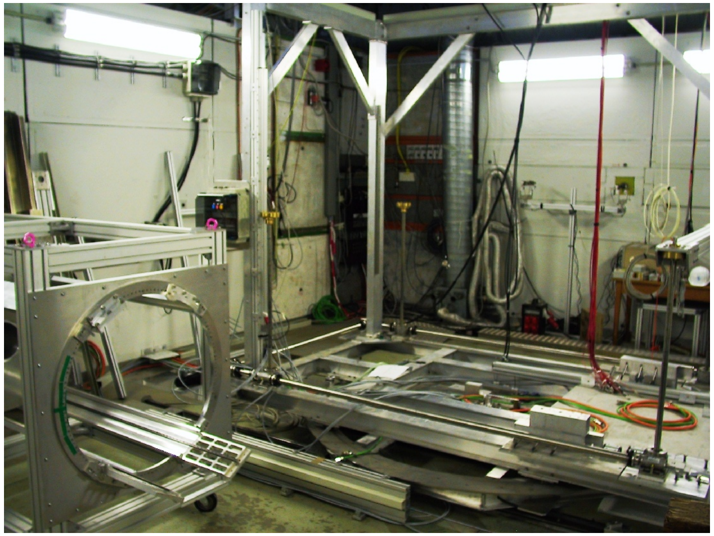


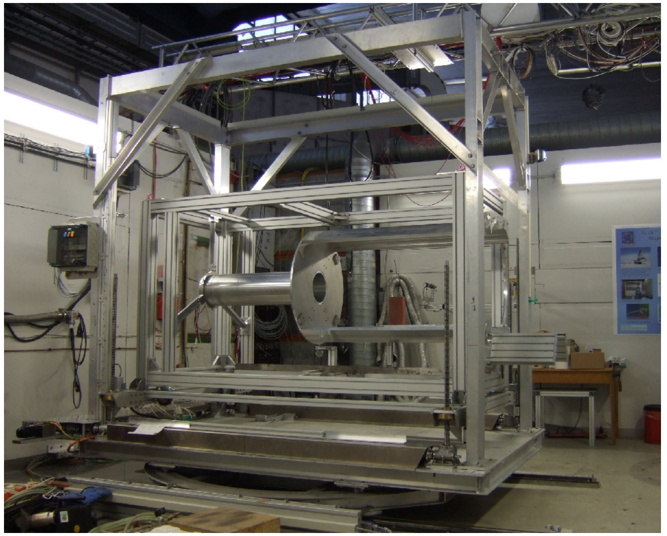
Time Schedule I



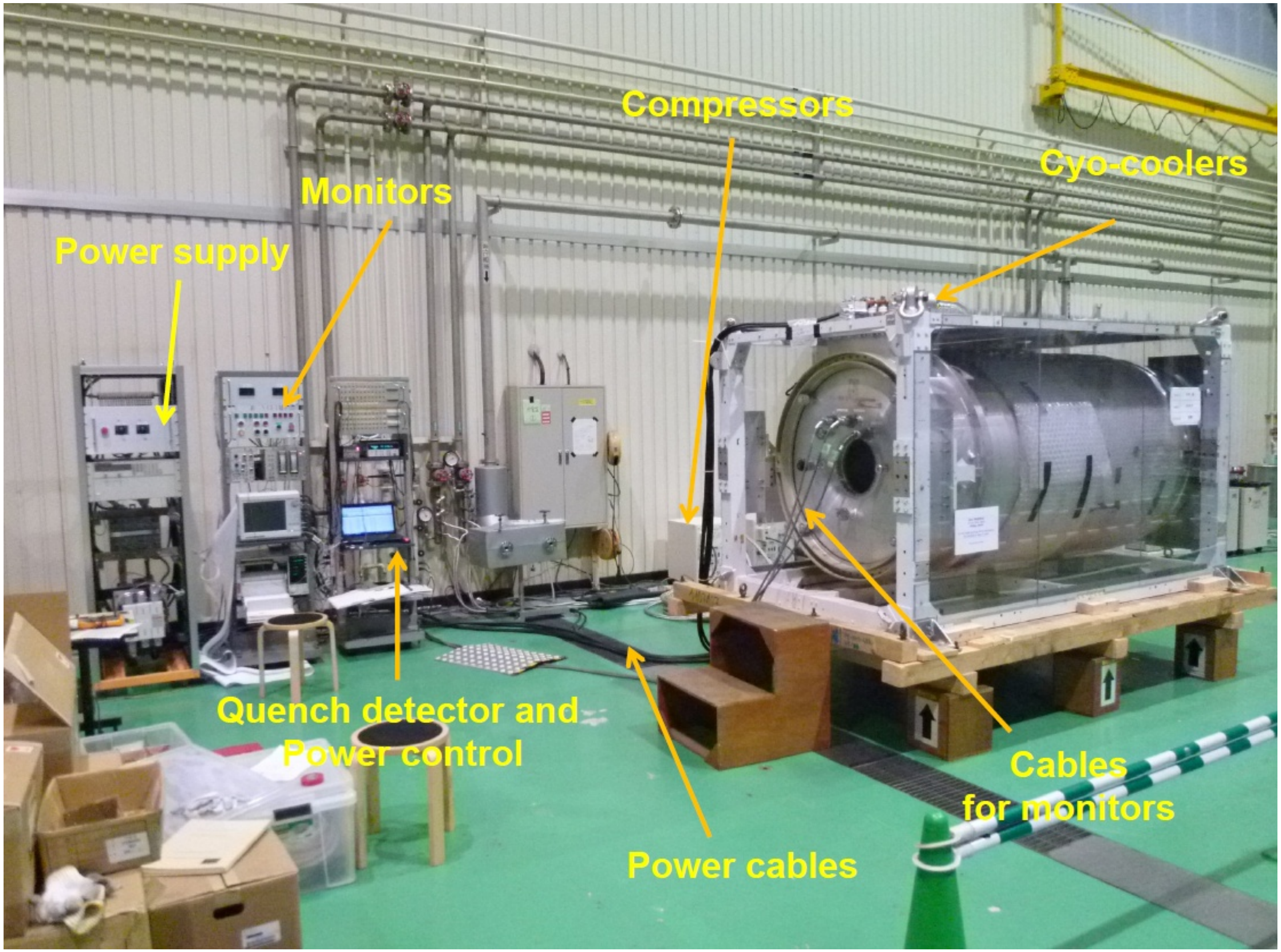
- Shipping
  - Left DESY 26. July '11
  - Arrived at KEK 10. August
- During absence:
  work on the movable stage
  - Improved cabling including
    end switches, stop buttons and other safety devices
  - Position measurement system
  - Axis covers, improved holding structure, etc.





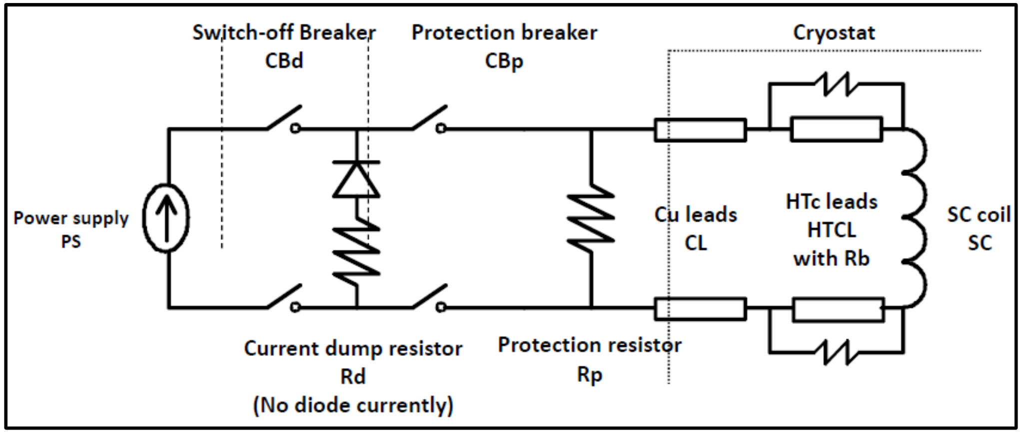


Test of Modified PCMAG



Test of Modified PCMAG

- March 10, 10:16h start of cooling
- March 19, 12:00h coil at 5K
  - 13:30h excitation in steps up to nominal current at 1T:
    10A → 100A → 200A → 300A → 400A → 432A
  - 17:50h 432A (by the shunt resistor) / 0.03V across the coil.
    Power Supply output : 445.21A at 2.195V
    Power supply settings: 445A and 2.5V
    (some voltage drops in the power cables and breakers)
  - 18:50h excitation stable for 1h; no change of temperatures, voltage or current
  - 18:55h breaker to ramp down magnet
    → coil quenched during
    switch off:
    temp. 50K,
    max voltage 59.572V
    → protection breaker triggered
    set to 1mV
    3mV over HTc current leads



- March 20, 00:40h coil cooled down again, test up to 200A, no damage observed
- March 21, 10:00h shipping out from Toshiba (coil still at 28K)

Time Schedule II

- Shipping:
    - Left from Toshiba/Keihin (Yokohama) on the 21. March
    - Arrival at Hamburg Airport: 24. March
- Installation:
  - April
    - Unpacking (second week) and installation of PCMAG in movable stage
    - Installation of additional power lines and cooling water lines
    - Prepare necessary items of the power supply and monitor system at KEK
  - May/June
    - Installation work at stage and alignment
    - Installation of compressors (cooling water, power & pressure lines)
    - Install magnet power cables, power & monitoring racks
    - Cooldown (start: end of May) → test runs:
      - Settings of dump resistor and quench protection limits
      - Study vibrations
- Finish system installation and test run till mid / end of June

Thanks to our Japanese colleagues
for keeping us up-to-date in the last months
and for supplying pictures and information
for this presentation